ARTICLE XIV.

Contributions to the Geology of the Tertiary Formations of Virginia. By William B. Rogers, Professor of Natural Philosophy in the University of Virginia, and Henry D. Rogers, Professor of Geology in the University of Pennsylvania. Read May 5th, 1835.

I. GEOLOGY OF A PORTION OF THE PENINSULA BETWEEN THE JAMES AND YORK RIVERS.

1. The region of which we are about to treat, comprises the counties of Elizabeth City, Warwick, York and James City, and the lower extremities of New Kent and Charles City counties. Its length in a north west direction is about fifty, and its mean breadth about fourteen miles. In Elizabeth City and Warwick counties, and the eastern portion of York county, the general level of the surface is but little elevated above tide. The country is a uniform flat, in some places subject to be occasionally overflowed. The rest of the region in question has an elevation above tide, varying from twenty to eighty feet. But few points, however, in the district have a level corresponding to either of these extremes, and by far the larger portion of the surface preserves a height of from forty to fifty feet.

2. The surface of this more elevated portion, though preserving a general level of remarkable uniformity, is deeply channelled by innumerable ravines. The smaller of these connect themselves with large ones, and these with the wider and deeper excavations forming

the beds of the creeks flowing into the James and York rivers. The system of ravines connected with one river, are separated by a narrow central tract from those connected with the other, and in a general view of the district, the two systems present the appearance of mere creeks or inlets, subordinate to the two great rivers bounding the peninsula.

3. The superficial stratum of the region we are describing is an argillaceous and ferruginous sand, of a yellow, and sometimes of a reddish colour, in which are occasionally found, at or near the surface, pebbles and small boulders of sandstone, rarely as much as six inches in diameter. The nature of these boulders would indicate that they were most probably derived from the sandstone formation which ranges along the eastern boundary of the primary ridge. In some places this stratum consists of little else than a white silicious sand; in others, the admixture of ochreous clay is so considerable, as to furnish a suitable material for the manufacture of bricks.

4. Beneath this superficial layer, beds of a very argillaceous clay occasionally occur, sometimes of considerable depth and extent, and of a texture to be useful in puddling. Its colour is various, being in some places a dark blue or green, in others a bright red or dingy yellow. Wherever found, its upper boundary is remarkably even and horizontal; but where it rests upon beds of fossil shells, its lower limit conforms to all the irregularities of surface which those beds usually present. Its appearance, in some places, is that of a steep, almost perpendicular wall of smooth surface, and divided by very narrow lines running horizontally. These narrow lines, at a distance of from five inches to a foot asunder, are formed by a more ferruginous and silicious clay. At Bellefield, on the York river, seven miles from Williamsburg, this deposit may be seen overlying the stratum containing shells, in some places having a thickness of from twelve to fifteen feet, and then gradually fining out and passing into a light coloured and coarser mass. The upper surface is horizontal, and the lines of division above alluded to are perfectly parallel and regular. The lower surface of the clay conforms to that of the shell stratum upon which it rests. In many places these argillaceous beds consist of a yellowish clay, beautifully variegated by streaks of red and blue.

5. A thin stratum of red ferruginous stone, containing a large proportion of oxide of iron, is found in this region, running horizontally below the beds of clay before described, and generally separated by only a few feet from the underlying masses of shells. This stratum, which is very generally present, varies in thickness from an inch to a foot. Its texture is sometimes cellular, sometimes compact and fibrous, like that of certain varieties of hematite.

6. The matter, which, in most cases, rests immediately upon the shells, is a yellowish brown sand, frequently containing a large proportion of clay. Throughout this mass, and often extending to the distance of five or six feet from the shells, particles of green sand, or the silicate of iron and potash, are more or less abundantly disseminated, and in the immediate vicinity of the shells these particles are generally condensed into narrow stripes, conforming in flexure to the irregularities of the bed beneath. Even where a deep hole exists in the layer of shells, the stripes of green sand are seen still following the depression and rise of the surface, and preserving a uniform distance from it. Sometimes these thin layers are so much indurated as to have almost the appearance of stone. In none of the strata above described have fossils of any description ever been discovered.

7. The materials with which the shells are intermixed, or in which they are embedded, have various characters. In some cases they consist principally of a nearly white sand; in others the argillaceous matter greatly predominates, and the mass is a somewhat tenacious clay. Frequently much oxide of iron is mingled with the earthy matter, giving it more or less of a yellow or brown appearance, and this is the aspect which the upper beds containing shells most usually present. Very generally the lowest visible fossiliferous stratum is composed of a green silicious sand, and a bluish clay, which being always very moist, is soft and tenacious, and presents a dark blue or black colour. At the base of the cliffs on the James and York rivers, this stratum may be traced continuously for considerable distances, rarely rising more than two or three feet above the level of the water, and presenting an even horizontal outline. In the deep ravines, and low down in the banks of shells, generally, throughout this region, a

similar dark bluish-green argillaceous sand is observed, enclosing frequently a great number and variety of shells.

The very general existence of the lower stratum, here described, forms an interesting and prominent feature in the geology of the Miocene Tertiary districts, as well of eastern Virginia as of Maryland. Throughout all the upper fossiliferous strata, as well as in the argillaceous beds just mentioned, will be found disseminated, greenish-black grains of silicate of iron and potash, identical with those already described as existing in the stratum immediately overlying the shells, and having the same form and composition with the granules contained very abundantly in an older Formation, both in this country and Europe. In some beds of the marl, or shells, these particles so abound as to give a very decided colour to the whole mass. In specimens from James City and York counties, as much as thirty-five per cent of the green sand has been found, and occasionally shells are seen filled with this substance almost alone.

7. The surface of the strata containing shells is usually irregular. Sometimes it rises abruptly, in the form of a hillock; then it is scooped out into depressions of a few feet in depth. These irregularities, however, are apparently of two kinds; the one the original form of the deposit, the other produced by denuding action upon the surface. Thus in many places the same stratum may be remarked rising with more or less abruptness; then again descending, and perhaps preserving a nearly horizontal line for some distance, marked at its upper surface by a clear and unbroken outline, and presenting no indication of violent abrasion from above. In other places, and this is a very frequent occurrence, deep and irregular furrows and cavities are seen, such as would naturally arise from the action of the currents and eddies of a large mass of water in rapid movement.

8. Having thus given an account of the nature and arrangement of the strata overlying the shells, as well as those in which they are imbedded, we will now describe the general condition and disposition in which the shells occur.

9. Condition of the shells in the tertiary deposits.

In general, the state of the shells, and their arrangement in the earth, are such as to indicate their tranquil deposition at the spots in which

they are found. Thus the corresponding valves are very often found together and closely shut. Many of the smaller shells, such as Arca centenaria, Arca incile, Nuculae, Venericardia alticosta, and Chama congregata, which are most usually thus found, are often either entirely empty, or contain a small quantity of clay that is quite impalpable; indicating plainly that they have been exposed to no violence, and that only such solid matter as could pass between the edges of the closed valves had obtained access to the interior. Whenever such shells, however, have been previously drilled, as is very frequently the case even with the largest and thickest shells, the interior is found entirely filled with sand, clay, green sand, and small fragments of shell. In most cases the larger species of shells, even when their valves appear to be in accurate juxtaposition, is thus filled, and in this case it cannot be supposed that the contained matter has entered through the holes thus drilled, since in many instances shells of considerable magnitude are found imprisoned within. Such shells, no doubt, after the death of the animal, remained open, or at least partially so, and received the sand, clay and other materials which they contain by the *gentle* action of the waves. The ligament at the hinge in the mean time would decay, until at length yielding to the pressure of the accumulating matter above the shell, in favourable circumstances would collapse into its natural closed condition.

The very common occurrence of the valves in juxtaposition, is a striking proof that during or subsequent to their deposition they have not been exposed to violent agencies. This becomes even more remarkable in the case of such shells as the Panopea reflexa, which almost in every instance is found with the valves properly united. The connection between the two valves in this shell is the slightest imaginable after the destruction of the natural organic bond, and an inconsiderable force would have sufficed to separate and break the valves.

10. The admirable preservation of the shells in many cases is also an interesting fact, and affords another evidence of the absence of all violent agencies at this period. The most fragile species of Natica, delicate Tellinae, Mactra tellinoides, the shell and processes of the Crepidula, the minute and sharp angles of the Fusus tetricus, the thin

and hollow Fissurella are found in perfect preservation in many places. The state of the shells seems to depend chiefly upon the mechanical texture and chemical character of the materials with which they are mixed, and of which the overlying stratum is composed. In the moist blue clay the shells are generally found in a very soft condition. In a highly ferruginous clayey bed they are found either partially or entirely dissolved, and beautiful casts remain in their stead.

11. In many places entire banks occur, composed of casts of Chama and other shells, sometimes separate, sometimes cemented together so as to form a species of rock. These appearances occur chiefly near the surface, and when the soil is porous and ferruginous. The casts thus formed often consist chiefly of carbonate of lime, and in many specimens as much as eighty per cent of this substance is found. Casts of this kind belong mostly to the smaller shells, and by far the most common are of the Chama congregata. These, as already stated, are often found nearly or quite empty, and we may, therefore, conceive, that as the matter of the shell in an extensive bank of Chamas is gradually dissolved, the water charged with carbonate of lime enters the cavities, and slowly deposits the carbonate mixed with fine particles of clay and sand. Thus by degrees the cavities are filled. In the mean time the shell disappears, frequently leaving on the surface of the cast a chalky covering, like the decomposed inner film of shelly matter. In support of this explanation it may be added, that in many casts beautiful crystals of carbonate of lime are found, forming a portion of the cast, and having the appearance of Dog-tooth Spar. In some cases the shelly matter appears to have been dissolved, and its place supplied by the crystallized carbonate, encrusting the earth formerly contained within the shell. Sometimes, too, a thin film of oxide of iron surrounds the cast, showing very distinctly all the markings of the inner surface of the shell. In many localities, presenting a series of beds differing in composition, the shells will be found perfect in some of them, while in others immediately above or below only casts remain. Thus at the College Mill, about one mile from Williamsburg, the upper fossiliferous layer is a yellow silicious sand, containing perfect shells. Below this is a brown *ferruginous* clay, filled with the most beautiful casts of Chama, Pectunculus, Turritella, &c.

The shelly matter has entirely disappeared, and the casts lie loosely in the cavities produced by the removal of the shells, entirely distinct from each other, and covered by a film of oxide of iron. The layer beneath, consisting of bluish-green silicious clay, is full of well preserved Pectens, Pernas, and a variety of other shells.

12. In general, the various species of shells are found associated in colonies or groups, but as in the case of banks of recent shells, these colonies contain many scattered specimens, differing from the general contents of the group. The two species of Chama, the C. congregata and C. corticosa, which are found in almost every deposit of shells in this region, in many cases form extensive beds, with a very small admixture of other genera. The best agricultural marl, of a purely calcareous nature, which is used in lower Virginia, is derived from these beds of Chama, the friable texture of the shell upon exposure to the air rendering this species of marl more easy of application to land, and more prompt in its ameliorating effects. Crassatellæ often form an extensive deposit, and the large Pectens occur in continuous layers of considerable depth and extent. The different species of Arca, Artemis, Crepidula, &c., present a similar arrangement. Even those shells which are of comparatively rare occurrence, are usually found in little groups. Thus the Isocardia fraterna is found, to the extent of a dozen or twenty, closely packed together. This gregarious assemblage of shells of the same species is what would naturally be anticipated in the absence of violent agencies during or after their deposition, and furnishes another very striking proof of the comparatively tranquil condition of the sea or estuary in which they were allowed to accumulate.

13. Disposition of the fossils.

In nearly all the vertical sections of the deposit we are now describing, a series of beds or strata may be observed, each distinguished by the predominance of one or more species, and the order of superposition of these beds frequently continues without interruption for some distance. It does not appear, however, that in localities remote from each other the arrangement of the shells is always alike, although in many instances there appears to be a striking correspondence. In a majority of cases in the neighbourhood of Williamsburg the upper layer

is composed principally of Chama congregata. In many localities also, the large Pectens mingled with Ostrea Virginica occupy the highest place. But generally, the same shell reappears as a predominant constituent of one or more of the subjacent beds; and such is the diversity of arrangement, even in places but a few miles distant, that it is obvious that no general order of succession exists. Thus in a range of three miles we find Perna maxillata in some localities in the lowest stratum of dark blue argillaceous sand; in others, forming an upper or even the highest layer of the series. At Waller's Mill, three miles from Williamsburg, this fossil overlies the other shells; whereas at the College Mill, as already stated, it forms a part of the lowest visible stratum. So far, therefore, as relates to the tertiary beds of the district of which we are now treating, and indeed of Virginia generally, there is no such constancy in the position of this fossil in the series, as to warrant the theoretical inference of its belonging to a different tertiary period, deduced by Mr Conrad from its relation to the other tertiary fossils in certain districts in Maryland.

14. With the view of conveying more precise ideas of the disposition of the fossils in this region, as well as describing some interesting facts peculiar to certain districts which have been investigated, we annex the following details in relation to some of the more important localities.

15. King's Mill, one of the most interesting fossil localities in the neighbourhood of Williamsburg, is situated on the north bank of the James river, about twenty-five miles from its mouth. The cliff in which the shells appear is abrupt, and has a height varying from twenty to forty-five feet above the water. The strata of shells extend along the river with slight interruptions, when the cliff sinks nearly to the level of the water, for a distance of between two and three miles, and they are found in a somewhat similar order of superposition for some distance inland. Their general direction is horizontal, but the outline of any one stratum is frequently very irregular, the surface rising and falling with a steep inclination. This irregular outline is particularly remarkable with the beds of Chama, which are very thick at some points, and then fine out rapidly and again expand.

16. This deposit of shells is covered to the depth of from four to

six feet by a brownish yellow sand, intermixed with stripes of clay. Beneath this is a thin layer of about one foot, of very argillaceous and ferruginous clay of a red colour. This rests upon a few inches thickness of gravel, consisting of water-worn quartz, rarely larger than a pea. Beneath this is a layer, from one to two feet thick, consisting of yellow sand, containing a great deal of the green or chloritic sand, arranged in narrow stripes. Next follows a layer of the same sand, containing principally Chama and Venus deformis. This is from two to three feet in thickness. Immediately below is a stratum consisting almost exclusively of Chama, with a few Arca centenaria, &c. This stratum, varying from three to four feet in thickness, is a mass of compacted shells, with but little earthy matter intervening. The earthy matter contains a very large proportion of the chloritic sand. The next stratum is composed chiefly of large Pectens, and has a thickness of from one to two feet. Below this is another dense stratum of Chama, together with Arca centenaria, Panopea reflexa, &c., and also very rich in the green sand. Thickness, from four to six feet. Then follows a second layer containing Pectens with Ostrea compressirostra, one foot in thickness. A third stratum, in which Chama predominates, follows next, in thickness from two to three feet, and at the base of the cliff is a layer containing Pectens, Ostrea compressirostra, &c., four to five feet in thickness.

17. Thus through a height of more than twenty feet in some places, the cliff consists principally of shells, of which there are a great many species, besides those mentioned as predominating in the several beds. On the extensive contiguous estates of King's Mill and Littletown, these shells are largely used as a manure: and for this purpose the first and second beds of Chama are preferred on account of the immense amount of calcareous matter, and the large proportion of green sand which they contain. Judging from the occasional appearance of bluish green-clay on the line of the beach, and in some places immediately at the base of the cliff just described, it is highly probable that a continuous stratum of this substance lies beneath the other beds throughout the whole extent observed. A horizontal bed of yellowish clay extends for some distance along a lower portion of the cliff, in which there are no fossils, running within a few feet of its upper edge, and beneath this bed, and parallel to it, is a thin layer of the iron ore

formerly described. At the foot of this cliff appears the underlying stratum of clay.

18. Description of the cliffs at Yorktown, on the York river.

The elevation, abrupt form, and peculiar structure of the cliffs at this point, and for some distance both above and below, render it an interesting spot to the geologist. A dry and ample beach, uninterrupted by creeks or inlets for several miles, affords a ready access to the banks; while the river's edge, strewed with fossils which have fallen from the cliff, exposes a considerable variety of interesting specimens. Immediately at York, the river is only three-eighths of a mile in width, but both above and below, it expands to a breadth six or seven times as great.

At Wormley's creek, about two miles below the town, the cliff about to be described begins; but from this point down to the extremity of the peninsula, the banks are uniformly flat and low. The cliff here consists at bottom of a bluish sandy clay, containing immense numbers of Turritella alticosta, Cytherea Sayana, and many small univalves, over which lies a layer of brownish yellow sand, with very few shells, and those chiefly Nucula limatula and a few other species. To this succeeds a stratum composed almost entirely of Crepidula costata, so closely packed together as to leave little space for sand or other earthy matter. The whole is covered to a variable depth by a stratum of coarse sand of various strong tints, and evidently highly ferruginous. The elevation of the cliff increases, and the nature of its contents gradually changes, in approaching York. The lower stratum disappears entirely after continuing for something less than half a mile, previous to which, however, its fossil contents are changed; the layer of the Turritellæ being replaced by Crepidula closely packed together. Crepidula still runs on horizontally above, and the intermediate stratum is now densely filled with Pectens, Venus deformis, Ostrea, and a great variety of small shells frequently connected together so as to form hard masses of considerable size. Still higher up the river the deposit assumes the character of successive layers composed of comminuted shells, connected together so as to form a porous rock. These fragments are generally s. small and so much rubbed and water-worn, as to render it impossible to ascertain the species of shell of which they

once were portions. Many small shells, and occasionally large ones, particularly Pectens, are found mingled with the other constituents of the rocks; and in some places thin layers of shells, such as Venus and Crepidula, intervene between the adjacent strata. The height of this fragmentary rock amounts in some places to forty feet. In most places it has a highly ferruginous aspect, though this is not invariably the case. Frequently shells of considerable size, such as Lucina anodonta, are seen coated with, or entirely changed into, crystalline carbonate of lime, firmly cemented in the mass. The texture of the rock is various, at some points admitting of being readily excavated by the pick and spade, so as to form caves which have been occasionally used by the inhabitants; in other places exhibiting a hard and semi-crystalline structure, and having the compactness of some forms of secondary limestone. The lower portion of the cliff, having less cohesion than the rest, has been scooped out by the action of water so as to give it, occasionally, an impending attitude.

Above the town the stratum of fragmentary rock becomes much thinner, being now reduced to about ten or twelve feet. A stratum of yellowish argillaceous clay, abounding in Artemis acetabulum, Mactras and other large shells, lies immediately beneath the rock; and lower still, appears the stratum of bluish clay, filled with Nucula limatula, several species of Fusus, and various other fossils.

A narrow layer of iron ore extends along the cliff, with occasional interruptions, at a small distance above the fossiliferous strata.

19. This fragmentary rock continues in a narrow band, with some interruptions, for about a mile and a half above York. Beyond this point it is met with chiefly in detached masses. Extensive beds of shells, similar to those which appear at York, come to view in the vicinity of Bellefield, and line the shore for a distance of about three miles. These beds rest on the usual stratum of sandy clay, and are in some places, as already described, covered by a stratum of the same substance. At a still remoter point, about six miles above York, on Jones's plantation, a porous rocky mass occurs, overlying the stratum of shells in a thin and interrupted layer. Though very similar in appearance to the fragmentary mass before described, and evidently at one time composed of portions of shells, it is almost devoid of any trace

of carbonate of lime. It appears to consist of silex, slightly tinged with oxide of iron; approaching in its porous character and harsh gritty texture to the nature of the burr-stone of France. Associated with this is a more compact rock, containing some carbonate of lime, with much silex, and exhibiting very perfect casts and impressions of Pectens, Cardium, &c. Over these strata is the usual layer of iron-stone, and the general aspect of the upper beds is somewhat ferruginous.

20. It is interesting to remark that, with some interruptions, a fragmentary deposit similar to that observed at York extends to the lower extremity of the peninsula. At Pocosin, a flat swampy country, which is often inundated by the tides, this deposit is uniformly met with by digging a few feet below the surface. Pectunculus, Pecten, Ostrea, as well as numerous small shells, occur mingled with it, as at York; the fragments, however, are not cemented together, but form a loose friable mass.

21. A very interesting feature in the structure of the cliff at York remains to be described. Though the general direction of the fossil beds is nearly horizontal, several of the strata of rock are composed of transverse layers parallel to each other, generally dipping towards the north, and making an angle of fifteen or twenty degrees with the horizon. The course of these laminæ sometimes differs in adjoining strata, and in some places the obliquity diminishes gradually until the laminæ become horizontal; thus presenting a remarkable resemblance to the appearances described by Lyell and others as existing in the Crag of England. The phenomenon here described, viewed in connexion with the fragmentary structure of the rock, and the general distribution of broken shells over the lower extremity of the peninsula, would seem to indicate the former agency in this district of coast currents and an ocean surf.

22. At Burwell's Mill, and other localities in the immediate neighbourhood of Williamsburg, nearly the same fossils occur as at King's Mill and Yorktown. Besides shells and Zoophytes, in these and other places in the peninsula, the bones of cetaceous animals and the teeth of sharks are of very frequent occurrence in the fossiliferous beds, but no remains of fresh water or land animals have as yet been discovered.

The total number of species of shells from these points which have yet been identified is about ninety-six, to which we will now add the following *new* species, recently discovered by ourselves. To this list others believed to be new, and at present under examination, will hereafter be added.

II. DESCRIPTION OF SOME NEW MIOCENE FOSSIL SHELLS.

Turritella ter-striata.

23. Whorls strongly angulated by three principal revolving elevated spiral ridges; the lowest, being about one-third from the base, is the most prominent; the second, which closely adjoins and almost coalesces with the first, is much feebler; the third, which is nearly one-third the height of the whorl from the summit, is more distinct and is separated from the second by a deep and wide channel; next the base of each whorl are three fine spiral striæ; others, to the number of four or five, occupy the space between the principal ridge and the summit; crossing these are very fine indistinct transverse arcuated wrinkles.

This shell is obviously distinct from the *variabilis* in the great inequality of the three principal ridges, the depth of the central channel, and the greater delicacy of the transverse wrinkles.

Locality, vicinity of Williamsburg; in the Miocene shell marl. Length, about two inches.

Turritella quadri-striata.

24. Shell turrited, regularly conical; whorls flattened, with four principal revolving equidistant spiral striæ; a fifth, less conspicuous, bounds the base of the whorl; the whole of these are alternated with five much smaller interposed striæ; near the summit of the whorls are traces of others yet more delicate; five transverse arcuated wrinkles, not very distinct.

Locality, Williamsburg, as before; length, one inch. This shell differs from the *variabilis* in the flatness of the whorls, and the number and relative proportion of the principal striæ; it is also a much more delicate and smaller shell.

Natica perspectiva.

25. Shell subglobose, smooth; substance of the shell rather thin; umbilicus open, with a rather prominent revolving rib, considerably above the middle of each volution, terminating at the labrum in a scarcely distinct callus; spire somewhat elevated and acute; aperture semicircular, five-eighths the length of the shell. Length, eight-tenths of an inch.

Locality, Williamsburg. Miocene. This shell resembles somewhat the *N. interna*, but it is obviously different in being less depressed, and in the form and proportions of the aperture; the general contour of the shell is also different.

Fissurella catilliformis.

26. Shell nearly elliptical, slightly subovate, depressed, conic, with approximate very regular longitudinal costæ, alternated with intervening striæ often very minute, the transverse concentric striæ giving a very uniform granulation to the costæ; foramen, oval, scarcely inclined; inner margin of aperture entire. Length, half an inch.

Locality, Shell banks, Prince George county. Miocene. This shell has some resemblance in its inner surface to the cavity of a dish.

Arca protracta.

27. Shell rather thick, very oblong transversely; ribs about forty, not very prominent, and hardly wider than the intercostal spaces, and longitudinally furrowed by three narrow grooves, the central one much the widest; a very indistinct granulation on the ribs, arising from the numerous minute transverse lines of growth crossing the longitudinal ridges of the ribs; beaks prominent and distant, opposite a point less than one-third the length of the hinge margin from the posterior extremity; area wide, with numerous distinct undulated grooves, parallel to the hinge margin; hinge margin rectilinear, with numerous minute straight teeth, those in the anterior half directed a little obliquely towards the anterior margin; posterior margin rounded slightly outwards, extending a little further backward than the angle; anterior margin much elongated, extending in an oval curve far in

advance of the end of the hinge; basal margin contracted opposite the middle of the hinge, and deeply crenate. Length, three and a half inches.

Locality, Shell banks, Prince George county. Miocene.

Lucina speciosa.

28. Shell sub-elliptical, inequilateral, inflated, rather thin, with equal close-set rather elevated longitudinal ribs, and regular very close concentric striæ; lunule small, very distinct, and ovate-lanceolate; beaks small, pointed, and slightly prominent beyond the general curve of the margin, placed about one-third the transverse length of the shell from the anterior end; cardinal teeth small, diverging; lateral teeth equal, distinct, and nearly equidistant from the anterior cardinal; hinge margin regularly arcuated, the rest of the margin, especially the posterior side, crenate within; posterior muscular impression elongated and slightly curved. Diameter, three-tenths; length, eleven-twentieths; height, nine-twentieths of an inch.

This very beautiful shell occurs in nearly all the localities of the Miocene in the James river region.

Venus cortinaria.

29. Shell sub-cordate, inflated, with very regular concentric, closely approximate, and very prominent imbricated ridges, which incline towards the beak, except the portion opposite the anterior, basal, and posterior margins, where they decline outwards towards the margin; beaks moderately prominent, about twice as far from the anterior as the posterior end; two anterior cardinal teeth, closely approximate above, second one of the left valve thick and sub-bifid; lunule wide, cordate; basal margin crenate within; posterior margin short, straight, and especially at the lunule finely crenate. Length, one inch; height, nine-tenths of an inch.

Locality, Williamsburg. Miocene. This beautiful shell rarely shows the concentric ridges perfect, from their prominence and thinness.

III. OF THE PLACE IN THE GEOLOGICAL SERIES TO WHICH THESE DEPOSITS BELONG.

30. That the strata here described, and the deposits identical and continuous with them, stretching extensively to the north and south into the adjoining states, are referable to the Miocene period of the American Tertiary, will be readily admitted on adverting to the well marked relations of their organic remains.

31. A careful summary of the fossils derived from the several localities hitherto examined within the peninsula, establishes the total number of those at present known to be very nearly one hundred. Of these not more than eighteen are ascertained to belong to species now living; showing a remarkable, though no doubt *accidental* coincidence with the average proportion of recent species found in deposits of the Miocene period in Europe.

Lest it may seem objectionable to institute the comparison between the recent and the extinct shells of several localities taken in the aggregate, the ratio has been examined as it exists in some of the localities separately. Thus in the cliffs at King's Mill on the James river, the whole number of species whose analogies are at present satisfactorily established, is about seventy-four, of which but fourteen are of the present day, or *recent*. The per-centage here disclosed is therefore about nineteen, being nearly the same with that above, and still almost identical with the proportions in several of the Miocene localities of Europe.

32. Making every possible allowance for future discoveries bringing to light as recent, some of the now supposed extinct species, it is still difficult to imagine, with such a ratio as we have at present, that the proportions can ever so far change as to make the living species of the deposit to equal or exceed the number of the extinct; a condition necessary of course to entitle it to the name of Older Pliocene, which it has received.

33. The circumstance that in Prince George county the Miocene is superimposed directly upon Eocene, from which it seems not to be separated by any features which would mark a long interval attended

by abrupt or violent actions, furnishes another, though not a decisive argument against its belonging to a period so late as the Older Pliocene. It seems reasonable to infer, that the two would hardly be seen resting together in exact conformability, as they do, had they been separated in time by the whole interval between the Eocene and the Older Pliocene, during which the surface of the former would be in a condition to undergo changes and irregularities nowhere perceived where they are seen in contact.*

IV. OF THE ORIGIN OF THE DEPOSIT OVERLYING THE MIOCENE SHELL MARL.

34. It is not easy, in the present state of our information, to approximate to the precise era when this overlying deposit was produced, though it appears to have had a date perhaps long anterior to the latest superficial diluvium with which it is often confounded. We infer this from the very general absence of all those signs which mark a trans-

* In a recent publication (Silliman's Journal, vol. 28, p. 106), Mr Conrad has attributed to a portion of the formation here under discussion, namely, the localities of Yorktown and the James river, near Smithfield, a date still more recent than the period of the Older Pliocene. He ranks those deposits, together with another at Suffolk, Virginia, and one on the St Mary's river, Maryland, under a new division, Medial Pliocene; it is stated at the same time that the recent species at those places compose about thirty per cent. A subdivision of the formation as it occurs in Maryland, characterized by Perna maxillata and a less proportion of recent species, is referred to the Older Pliocene, while the opinion is advanced that the Miocene is probably altogether wanting. Now to those familiar with the principles of the new nomenclature of the Tertiary, it is obvious that the beds, so styled, the Older as well as the Medial Pliocene, are entitled, in strictness, to the appellation of Miocene only.

To confer on a formation the name Medial Pliocene, its shells should contain about thirty per cent extinct, and seventy per cent recent, and not the *converse*. We believe, moreover, that the per-centage of recent species at Yorktown is even materially less than thirty.

In No. 3, of his work on American tertiary shells, issued a little earlier than the other article, Mr Conrad adopts a somewhat different classification, calling the several localities in Virginia and Maryland, Older Pliocene, as before, except that stratum low down in the Maryland formation which is distinguished by the Perna maxillata, and this he denominates Miocene. For reasons before stated, namely, the small per-centage of recent species throughout them *all*, we believe the whole together to have been produced in the Miocene epoch, and to belong to one formation; and we have been led into this note in the sincere wish to settle the question of the age of this division of our Atlantic Tertiary formations, lest the student of American geology be disheartened by the perplexity which grows out of a shifting and inconsistent nomenclature.

portation by violent causes from a distance, its materials being finely comminuted clays and sands usually arranged in a manner denoting a somewhat quiet deposition. On the other hand, its containing no fossils, its distinct separation from the fossiliferous marl stratum beneath it, the surface of which is furrowed and deeply channelled, as if an interval of erosive action had preceded it, are facts which may possibly displace it from the Miocene era altogether, and which, for the present at least, throw entire uncertainty upon the inquiry as to the position which it should occupy in the Tertiary series.

35. It is not unlikely, all things considered, that the origin of this deposit is to be traced in the rise from beneath the sea of some of the more western portions of the tide water plain; in other words, with the appearance above water of the Eocene tract in that quarter. This is rendered probable from the circumstance that this superficial bed often abounds near the *bottom* with grains of the green sand mineral so abundant in the Eocene of Virginia. It is corroborated, likewise, by the fact that the shelly Miocene stratum reposing upon the Eocene, sometimes shows tokens of considerable violence over its surface, the shells being, throughout a depth of several feet near the top, in a fragmentary state, and much disturbed, as may be seen in Prince George county, and on the Chickahominy river.

If we conceive that tracts in the Eocene district, or above it, were upheaved to near the water's level, or entirely out of it, while the country to the east was still submerged, we may not only explain the facts here mentioned, but by adverting to the nature of the actions which would supervene, we may account, by the sudden draining off of the uplifted water, for the eroded surface of the Miocene marl, and the sudden and total extinction of animal life which took place. To this would naturally succeed the introduction of nearly the same kind of matter under more tranquil circumstances, brought down from the newly exposed tract by river action, the probable source, we may conjecture, of some of the sands and clays of finer texture which occur so regularly and quietly stratified every where in the upper parts of the deposit.

Later than all these operations must have been the diluvial action, more or less extensive, which grooved the surface of this deposit

throughout the Tertiary region with its innumerable ravines and shallow valleys of excavation. Whether this last change was impressed upon the surface by the final emergence of the whole territory from the sea to its present level, or by some more universal denuding flood which has swept the continent generally, we venture not to decide; though the comparatively small amount of transported superficial pebbles and boulders, and the absence of any which can be traced beyond the nearest rocks at the head of tide, incline us to attribute the denudation in question to the supposed *local* action rather than to the other.

V. EOCENE FORMATION OF VIRGINIA.

36. Though some attention has been devoted by Mr Conrad, and other American naturalists, to the Tertiary fossils of several localities in Virginia, as yet their researches have been limited to such as appertain to the subordinate divisions of the Tertiary group, arranged by Mr Lyell under the head of Pliocene and Miocene; and though the existence of an Eocene deposit might naturally have been inferred, no locality of this character appears to have been known to them. The existence of an extensive Eocene formation in eastern Virginia is now for the first time announced, as furnishing an interesting step in the progress of the geological inquiries which are now on foot by legislative authority in that state.

37. This formation appears to have a general meridional direction, traversing the state from the Potomac to the Roanoke. It is intersected and exposed by the principal rivers, first making its appearance at from twenty to thirty miles below the primary ridge. The most interesting locality which has as yet been visited, and that from which the fossils have been most abundantly obtained, is on the James river, beginning a little above City Point, and extending nearly in a continuous manner to Coggins Point, a distance, following the flexures of the shore, of about eleven miles. At Coggins Point, Torbay and Evergreen, the cliffs have a height varying from thirty to forty feet. At the base, a stratum of what appears at first to be a blackish clay extends nearly horizontally throughout the whole distance, rising a little as it ascends the river. Its height above the water at Coggins

Point is about three feet, at Evergreen upwards of ten, measured to the upper edge of the stratum. It continues downwards to a depth of six or eight feet, and terminates in an argillaceous clay of a bluish-gray colour. This dark stratum consists largely of particles of green sand, or silicate of iron and potash. It contains a great number of Eocene fossils, among which are Cardita planicosta, Fusus longævis, &c. &c. already known as existing either in the Eocene of Paris or Alabama, or in both. But besides these it also contains a variety of beautiful and new species, some of which will be described in the present paper. These shells are, at some points, almost entirely dissolved, and very perfect casts alone can be procured; but at other points, though in a soft condition, they can, by using great care, be obtained in an entire state.

38. Above this stratum is a layer of what Mr Edmund Ruffin, the able editor of the Farmer's Register of Virginia, calls gypseous earth. This stratum appears once to have abounded in fossils, but at present only casts, and those in a very soft condition, can be found. They are, however, identical with the fossils of the lower stratum. The earth of this layer, besides a considerable proportion of green sand, contains a large amount of sulphate of lime, disseminated in minute grains, and grouped in large and massive crystals. Immediately above occurs a thin stratum of white clay, at the junction of which with the former layer the crystallized gypsum is found in great abundance, and almost perfectly pure. Above the clay is a stratum of shells in a very disintegrated condition, but consisting of Ostrea sellæformis and other Eocene fossils, and immediately above is a stratum of the shells of our middle Tertiary. A few scattered pebbles of a brown hue, hardly numerous enough to form a stratum, separate these two very distinct formations. In this uppermost layer are found the common Pecten and Pectunculus of our middle Tertiary.* The whole thickness of the Eocene deposit

* Among the interesting fossils of the middle Tertiary above, is an enormous specimen of Astrea, which is worthy of being described. This mass was some years ago disengaged from the upper part of the cliff at Torbay, and is now lying on the shore, firmly fixed in the sand and clay. Though it has been much reduced in size since its fall, it is still of immense magnitude. Its form is of course very irregular, but its largest diameter may be estimated at four

at this point appears to be about twenty feet. At distant points, where this deposit has been examined, as for instance near the Piping Tree, on Pamunkey, and near Port Royal, on the Rappahannock, as well as upon the Potomac, much the same arrangement and succession of strata have been remarked.

39. The section at Coggins Point presents the interesting feature of a juxtaposition in the same cliff, of the Eocene and newer Tertiary formations, and on this account must be regarded as an important locality.

The fact too that in this as well as other places where the Eocene deposit has been discovered, so very large a proportion of the chloritic sand is contained in the matter embedding the fossils, is, we presume, an unexpected and interesting circumstance. Even the New Jersey secondary strata are seldom more abundant in this peculiar mineral product than the formation referred to, and hence the farmers of Virginia are beginning to apply this material to their fields.

VI. NEW FOSSIL SHELLS OF THE EOCENE OF VIRGINIA.

Nucula cultelliformis.

40. Shell ovate, ensiform, somewhat inflated, rounded before, much elongated, and tapering behind, the posterior length more than twice the anterior, furnished with very fine, hardly distinct concentric striæ, and one distinct and one very obscure rib behind; anterior part with an indistinct fold; shell thin; lunule long and lanceolate; beak small; anterior series of the teeth gently arched; posterior series straight; teeth in both acutely bent, the angles directed towards the beak; margin entire; cavity of shell shallow, with a ridge passing from the beak to the posterior margin. Transverse length, twenty-eight hundredths; height, eight hundredths of an inch.

Locality, Coggins Point, Prince George county, in the green sand stratum. This very delicate shell approaches nearest to the *N. media* of Lea, the Æqualis of Conrad, but differs in the great elongation of

and a half feet; and its weight is probably seven or eight hundred pounds. On the shore are likewise found vast numbers of the teeth of sharks, some of them of enormous dimensions.

the posterior end, in the ribs, and in the less distinctness of the transverse striæ.

Nucula parva.

41. Shell ovate, inflated, rounded before, not much produced, but rapidly tapering to a truncated point behind, furnished with about twelve rather coarse concentric folds or ridges, and a longitudinal gently depressed groove or undulation of surface, running from near the beak to the posterior basal margin; beaks nearly central; anterior series of teeth slightly arched; posterior series nearly straight; margin entire; cavity rather deep. Length, three-twentieths; height, two-twentieths of an inch.

Locality, same as the preceding.

Ostrea sinuosa.

42. Shell sub-orbicular, or equilaterally sub-triangular; inferior valve moderately convex, with the laminæ of growth profoundly plicated into loops, which are imbricated so as to produce regularly radiating ribs; hinge-plane depressed, and in a line with the dorsal margin, which is long and straight, the sides of the inferior valve being dilated into the form of ears; fosset placed symmetrically and centrally in the hinge, and less than one-third its length, and curving suddenly at its termination in a narrow groove; beak slightly curved to the right and truncate; muscular impression small; inferior valve very slightly convex or flat, nearly circular, with concentric almost circular wrinkles. Length of the specimen four and a half inches; diameter between the ears five and a half inches; diameter of flat valve four inches.

Locality, Evergreen, James river, in the lower or green sand stratum of the Eocene. This very beautiful fossil oyster will be seen to differ from the *O. compressirostra* in several essential particulars, especially in the structure of the hinge, in the more symmetrical and profound plications on the inferior valve, in its less convexity, and in its more regular dilatation on the upper margin into partial ears.

Cytherea ovata.

43. Shell subovate, somewhat inflated, with concentric transverse

striæ, very fine near the umbones, but much coarser near the margin; beaks rather elevated; lunule very indistinct; teeth elevated and straight, the two posterior ones of the left valve small, much compressed, approximate, and nearly parallel; the anterior tooth large and grooved by a deep canal; cavity of shell deep; margin entire; posterior margin straight, and separated from the muscular impression by a fold or groove. Length, one inch and one-tenth; height eighty-five hundredths of an inch.

Locality, Coggins Point, in the Eocene green sand.